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DCPA ATTACK ENVIRONMENT MANUAL

CHAPTER 5

WHAT THE PLANNER NEEDS TO KNOW ABOUT INITIAL NUCLEAR RADIATION

DEFENSE CIVIL PREPAREDNESS AGENCY
DEPARTMENT OF DEFENSE

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DCPA ATTACK ENVIRONMENT MANUAL

WHAT THE EMERGENCY PLANNER NEEDS TO KNOW ABOUT THE NATURE OF NUCLEAR WAR

No one has gone through a nuclear war. This means there aren't any natural experts. But civil defense officials are in the business of preparing against the possibility of nuclear war. Intelligent preparations should be based on a good understanding of the operating conditions that may occur in a war that has never occurred. Lacking such understanding, emergency operating plans probably won't make much sense if they have to be used.

This manual has been prepared to help the emergency planner understand what the next war may be like. It contains information gathered from two decades of study of the effects of nuclear weapons and the feasibility of civil defense actions, numerous operational studies and exercises, nuclear test experience, and limited experience in wartime and peacetime disasters that approximate some of the operating situations that may be experienced in a nuclear attack. In short, it summarizes what the Defense Civil Preparedness Agency now knows about the nuclear attack environment as it may affect operational readiness at the local level.

PREFACE TO CHAPTER 5

This discussion of initial nuclear radiation also introduces the planner and emergency operator to the biological effects of brief exposures to ionizing radiation. It is assumed that the reader is familiar with the material in the preceding chapters. Since initial nuclear radiation is most significant for low-yield nuclear detonations (ranging up to 1 megaton), other effects of detonations from 40 to several hundred kilotons (changes in blast and fire effects) have been included. Chapter 5 is the only chapter in this Manual that discusses the effects of "small" nuclear weapons.

Information is presented in the form of "panels," each consisting of a page of text and an associated sketch, photograph, chart, or other visual image. Each panel covers a topic. This preface is like a panel, with the list of topics in Chapter 5 shown opposite. If the graphic portion is converted into slides or vugraphs, the chapter or any part can be used in an illustrated lecture or briefing, should that be desired.

The ordering of topics begins with two introductory panels, followed by five panels on the nature of radiation injury. Two panels summarize the relationship of the initial nuclear radiation (INR) threat to blast effects for megaton-yield weapons and the protection afforded by shelter areas. There follow three panels on the more serious INR threat from "small" nuclear weapons. Two panels discuss how the blast and fire effects of these "small" weapons differ from the effects described in Chapters 2 and 3. Finally, the planning implications of initial nuclear radiation are summarized. A list of suggested additional reading is included for those who are interested in further information on the general subject.

CONTENTS OF CHAPTER 5

"WHAT THE PLANNER NEEDS TO KNOW ABOUT INITIAL NUCLEAR RADIATION"

INITIAL NUCLEAR RADIATION

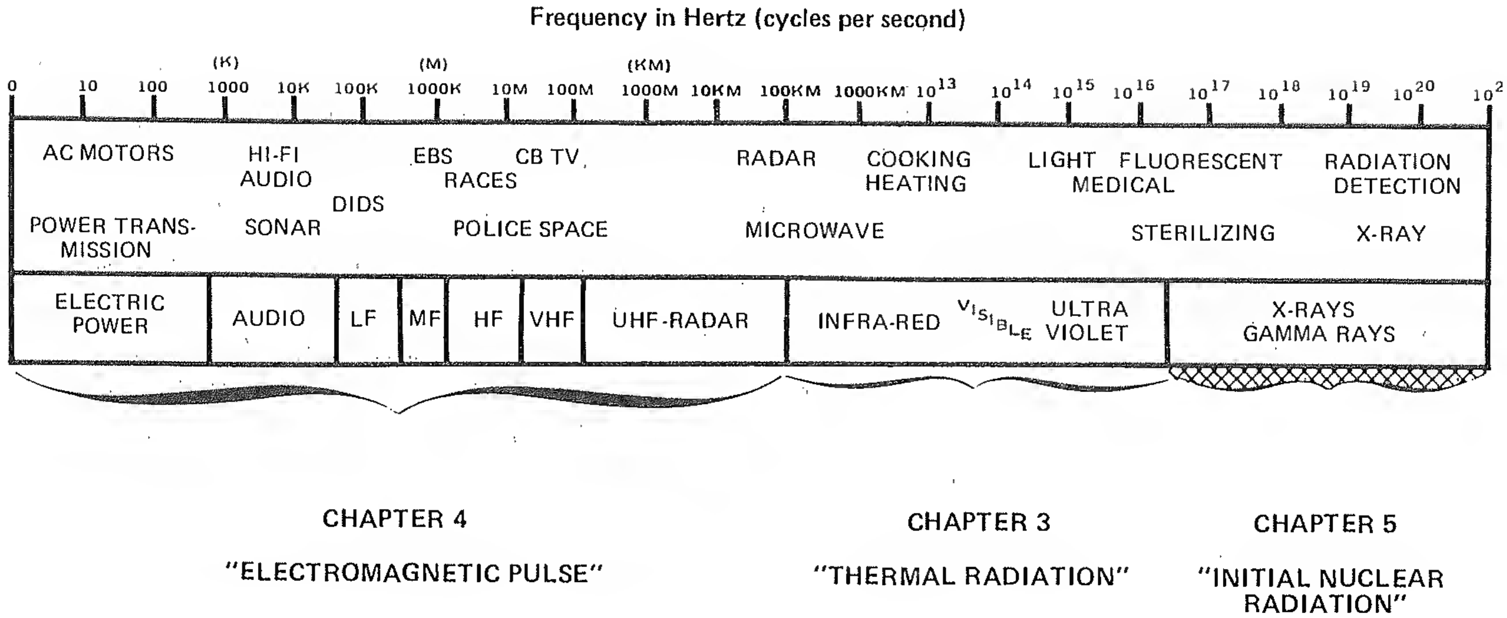
In Chapter 3, the effects of a pulse of electromagnetic radiation in the "thermal," mainly infra-red, band of frequencies were explained. This thermal pulse of radiant energy could cause burns to exposed people and start fires in light combustible materials. In Chapter 4, the effects of the electromagnetic pulse of frequencies below the infra-red band were discussed. This "EMP" energy was found to be collected by electrical conductors so that it could cause damage to electronic and electrical equipment. In this Chapter, we will be concerned mainly with gamma radiation, electromagnetic radiation of extremely high frequency, and consequent very short wavelength, as shown on this chart.

Most people are familiar with the medical use of X-rays. X-rays are produced when a stream of high-energy electrons is directed against an object. Each element of matter gives off X-rays of characteristic frequencies when bombarded in such fashion. X-rays affect a photographic plate in a way similar to light. The absorption of X-rays in matter depends on the density and composition of the material. Thus, bones absorb more X-rays than the surrounding tissue. This makes it possible to take an X-ray photograph of the bones and organs of a living person. Most people have had such "X-rays" taken at one time or another.

It has been customary to classify electromagnetic radiations by their cause or mode of origin. But the interaction of these radiations with matter is independent of the mode of origin. For practical purposes, gamma rays are like X-rays but they are emitted as the result of changes in the nucleus of the atom. Gamma rays are **nuclear** radiation whereas X-rays are not. The consequences are much the same except that gamma rays are generally more penetrating and, indeed, photographic film is used to measure quantities of gamma radiation as well as X-radiation.

Initial nuclear radiation has been somewhat arbitrarily defined as that nuclear radiation emitted during the first minute following the detonation of a nuclear weapon. This time interval was initially chosen on the basis that by one minute the rising fireball and nuclear cloud would be too remote from the earth's surface to cause any significant effects. Actually, the main exposure to initial nuclear radiation occurs in a much shorter time interval.

THE ELECTROMAGNETIC RADIATION SPECTRUM



PANEL 1

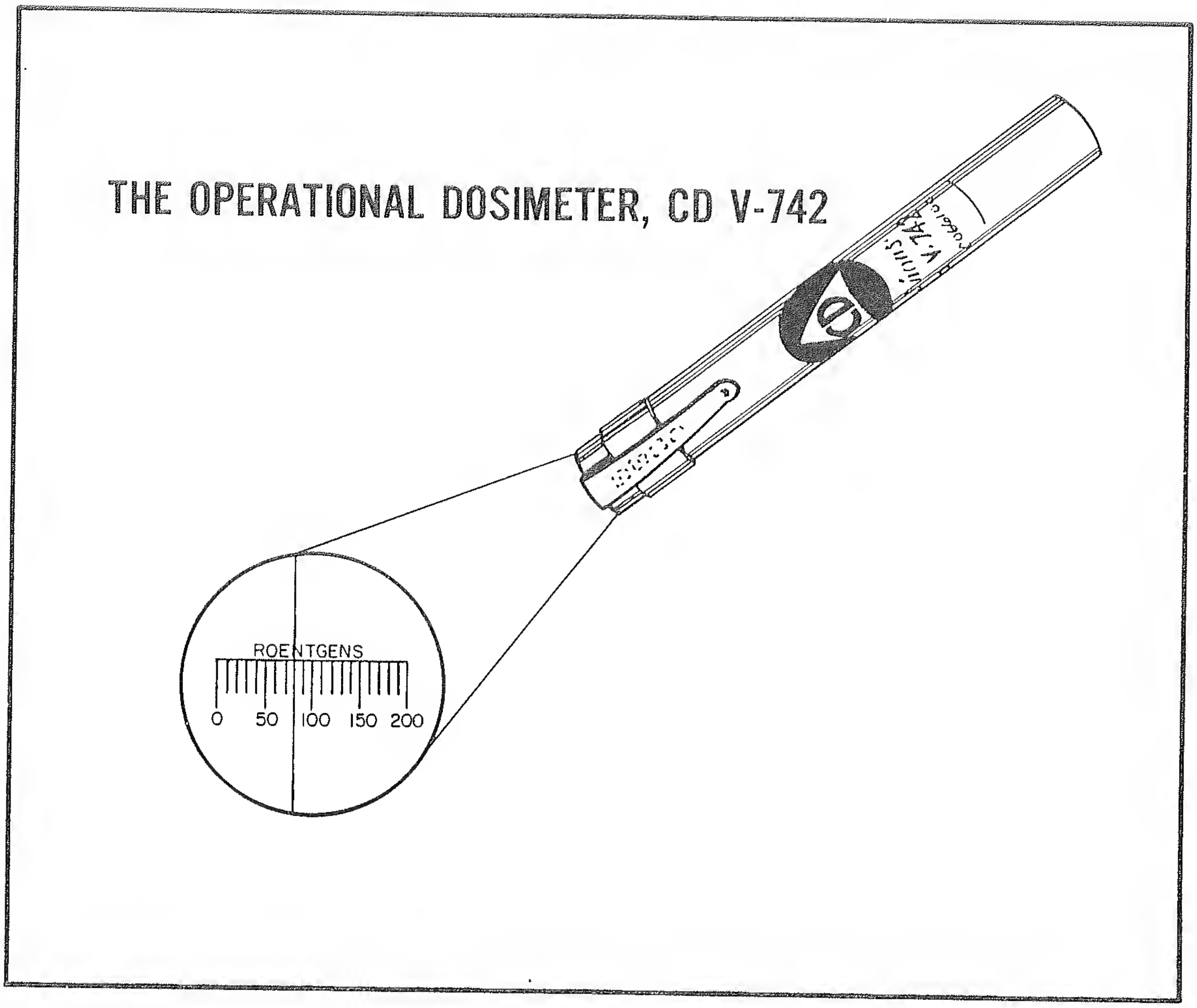
GAMMA RADIATION

Gamma rays are the main initial nuclear radiation from megaton and larger nuclear detonations. We saw in Chapter 3 that thermal radiation is largely absorbed in the surface layers of materials and living things. Thus, thin combustibles may flame but thick materials merely char. Gamma radiation, on the other hand, is highly penetrating; even large masses of earth or concrete will not completely absorb it.

In penetrating materials, including air, gamma rays may be absorbed or changed in direction (scattered) through interaction with the atoms of the material. When gamma rays are absorbed, ions are formed. An ion is an electrically charged atom or group of atoms. Gamma radiation is a form of **ionizing** radiation.

Exposure to gamma radiation is measured by the amount of ionization produced in air. The special unit of exposure is the Roentgen (R). The device shown here, called a dosimeter, reacts to the ionization produced by gamma radiation and, hence, measures the radiation exposure in Roentgens.

PANEL 2



The Operational Dosimeter, CD V-742

RADIATION INJURY

Emergency planners will be concerned with gamma radiation because of its capacity to injure people. Injury is caused by the ionization produced in the body by gamma radiation. Broadly speaking, ionizing radiation acts more like cumulative chemical poisons than like physical causes of injury, such as blast, missiles, and thermal radiation. Like chemicals, large single doses can cause severe acute sickness or death, depending on the size of the dose and individual susceptibility. On the other hand, small daily doses can be incurred over extended periods of time without causing illness, although delayed consequences may become apparent in later life.

Initial nuclear radiation is a single brief pulse of ionizing radiation. Most of the available information about acute radiation injury is based on experience with single, large doses. Although much of the information is indirect, more is known about radiation than about most other injurious agents, such as war gas, blast, and the like.

Radiation injury is a collective term used to describe all kinds of biological effects grading in severity from the undetectable to the fatal. The effects of a brief exposure that are known with greatest confidence are shown on this table. Lethal doses—those that are likely to kill 10 percent, 50 percent, or 100 percent of those exposed, are known with less confidence. A given dose of radiation will not have the same effect on everyone. Differences in susceptibility among individuals is characteristic of all living creatures. In laboratory studies of the effects of radiation and toxic chemicals on animals, this variation in response makes it useful to determine the dose that will kill half the animals exposed. This is called the median lethal dose (MLD). The best estimate of the MLD for humans is 450R. The dose that causes few deaths (odds of surviving about 20 to 1) is about half the MLD. The 95 percent lethal dose (odds of surviving are 1 in 20) is less than twice the MLD.

It will be noted that the term, "dose," is used for radiation as it is for toxic chemicals. Another term that the planner may encounter is the "rad," the standard unit for absorbed radiation. For gamma radiation, the rad is about equal to the Roentgen measure of exposure. The emergency planner can regard these terms as interchangeable, for practical purposes.

EFFECTS OF A BRIEF GAMMA DOSE*

Smallest exposure detectable by statistical study of blood counts of a large group of exposed people	15R
Smallest exposure detectable in an exposed individual by laboratory means	50R
Smallest exposure that causes vomiting on day of exposure in about 10 percent of exposed people	75R
Smallest exposure that causes loss of hair in second week in about 10 percent of exposed people	100R
Largest exposure that does NOT cause illness severe enough to require medical care in majority of exposed people	200R

*Adapted from National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

PANEL 3

RADIATION SICKNESS

The short-term consequences of over-exposure to gamma radiation have been called radiation sickness. Signs and symptoms associated with the digestive system are those seen earliest and at the lowest exposure levels. The table shows the exposures that will cause a 50 percent incidence of various symptoms of radiation sickness, based on clinical data from irradiated hospital patients.

The blood-forming organs, mainly the bone marrow, are also sensitive parts of the body. Observable signs of blood changes develop later and at higher exposures. These changes result in lowering of the resistance to infection. When fatalities occur, they are often the result of complicating infection. At very high levels of exposure, the central nervous system can be affected.

Radiation sickness is not a communicable disease. It cannot be transmitted to others. In this respect, it is similar to chemical or food poisoning. Indeed, the problem is not protecting others from the radiation victim, but rather protecting the radiation victim from infection from others.

Another point to be noted in the table is that the symptoms that occur earliest and after lowest exposures—particularly nausea and vomiting—are symptoms also of simple anxiety, stress, and fear. Moreover, one or two persons exhibiting these symptoms in a crowded, close environment can induce nausea and vomiting in others. Since radiation injury itself is not painful or otherwise apparent until symptoms of sickness appear, random reactions to the stress of the emergency could be erroneously interpreted as radiation sickness.

ESTIMATED SINGLE RADIATION EXPOSURES THAT
WILL CAUSE 50 PERCENT INCIDENCE OF SYMPTOMS

Signs and Symptoms of Radiation Sickness	Single Exposure (Roentgens)	95 Percent Confidence Range (R)
Loss of Appetite	180	150 - 210
Nausea	260	220 - 290
Fatigue	280	230 - 310
Vomiting	320	290 - 360
Diarrhea	360	310 - 410

PANEL 4

LEVELS OF SICKNESS

The general course of radiation sickness can be described in understandable terms. It is described here because most people have little knowledge of it and some familiarity may aid in emergency planning. Grim as some of the description is, it is no more grim than the consequences of massive burns or blast injury.

Unapparent radiation injury occurs when the brief exposure is less than 50R. Level I radiation sickness occurs in the exposure range of 50R to 200R. At this level, less than half the persons so exposed will vomit within 24 hours. There are either no subsequent symptoms, or, at most, only easy fatigability. Less than 5 percent will require medical care for radiation injury. Others can perform their customary tasks. Deaths that occur are caused by complications such as blast and thermal injuries or infections and debilitating disease.

At Level II shown in the table, more than half the persons will vomit soon after exposure and will be ill for several days. This will be followed by a period of one to three weeks when there are few or no symptoms. At the end of this latent period, epilation (loss of hair) will be seen in more than half, followed by a moderately severe illness due primarily to the damage to the blood-forming organs. Most of the people in this group require medical care. More than half will survive, with the chances of survival being better for those who received the smaller doses. Note that early and widespread illness does not necessarily make survival unlikely.

The Level III illness is a more serious version of that described for Level II. The initial period of illness is longer, the latent period shorter, and the ensuing illness is characterized by extensive hemorrhages and complicating infections. Hospitalization is desirable and less than half will survive.

Level IV is an accelerated version of Level III. All in the group will begin to vomit soon after exposure and this will continue for several days or until death, which occurs before the end of the second week, and usually before the appearance of hemorrhages or epilation. Level V is an extremely severe illness in which damage to the brain and nervous system predominates. Symptoms, signs, and rapid prostration come on almost as soon as the dose has been received. Death occurs in a few hours or a few days. Illness of this type has been seen after accidents involving exposure to gamma radiation in excess of several thousand Roentgens.

SUMMARY OF RELATIONSHIP BETWEEN EXPOSURE AND LEVEL OF RADIATION SICKNESS*

Exposure Range	Type of Injury	Probable Mortality Rate Within 6 Months of Exposure
0 - 50R	No observable signs or Symptoms	None
50 - 200R	Level I Sickness	Less than 5 percent
200 - 450R	Level II Sickness	Less than 50 percent
450 - 600R	Level III Sickness	More than 50 percent
More than 600R	Levels IV & V Sickness	100 percent

*Adapted from National Committee on Radiation Protection, **Exposure to Radiation in an Emergency**, Report No. 29, January 1962.

LATER CONSEQUENCES OF RADIATION INJURY

In addition to radiation sickness during the emergency period, other signs of radiation injury can occur many months or years after exposure. These late effects are categorized as somatic effects, those occurring in the individual exposed, and genetic effects, those occurring in children of exposed individuals and in subsequent generations.

Late somatic effects include those listed here. None of these conditions is caused uniquely by radiation. What the addition of radiation does, apparently, is to increase the probability of these effects over the standard rate for people of a given age.

Sterility or reduced fertility occurs in many cases of non-fatal radiation sickness, but is temporary in most people. Recovery of fertility may take as long as several years. The risk of developing leukemia is definitely increased by exposure to gamma radiation. Leukemia has appeared in some of the Japanese who were exposed to initial nuclear radiation at Hiroshima and Nagasaki, with the majority of excess cases occurring in the first ten years. The increased incidence appears to be proportional to the dose received. Among the Japanese who survived the largest doses (that is, those who were closest to the detonation) the incidence was about 50 times the standard rate. For future heavily-exposed survivors, this would mean that about 1.5 percent of those aged 25 to 34, for example, might develop leukemia during a 10-year period instead of 0.03 percent, which is the standard 10-year risk rate for leukemia in this age group in the United States.

Among the Japanese who survived at Hiroshima and Nagasaki, there were about as many cases of cataracts as leukemia—about 100 to 150 cases. All but two of these consisted of minor opacity of the lens that did not interfere with vision. Other late effects, such as life-shortening, are not based on human evidence. Experiments on animals suggest that each Roentgen of total-body gamma radiation may shorten life by one to ten days. As to fetal irradiation, most pregnant women in Japan who suffered radiation sickness had a miscarriage as a consequence. A few babies were delivered successfully, but there is no reliable basis for predicting the consequences of radiation injury to unborn children.

LATER SOMATIC EFFECTS

Reduced Fertility

Sterility

Leukemia

Cataracts

Other Cancers

Life Shortening

Fetal Injury

PANEL 6

SOMATIC AND GENETIC EFFECTS

The statements shown here were made in 1967 by Dr. Charles L. Dunham, Chairman of the Division of Medical Sciences, National Research Council. He was summarizing the views of the professional community at a symposium on the consequences of a nuclear war in which about 3500 megatons were assumed to be detonated in the United States. As we saw in Chapter 1, an attack perhaps twice as heavy could be delivered today. In the larger war, the number of survivors would be less but the average radiation dose received by the survivors would be much the same as Dr. Dunham's assumption of 200R. The first quotation refers to the late somatic effects discussed in the previous panel. For perspective, about 20,000 new cases of leukemia are diagnosed each year in the U.S. About 69,000 deaths occurred from lung cancer in 1971, most due to smoking.

The second quotation refers to the genetic effects—those affecting future generations. Genetic injury does not affect the health of exposed individuals in any way and can be detected only by statistical studies of their descendents. So far, searches for evidence of abnormalities in children conceived after one or both of the parents were irradiated have been unsuccessful. Using pessimistic assumptions, calculations have been made that suggest that major defects in newborn babies of succeeding generations might increase to 5 percent from the present rate of 4 percent, assuming that all parents received a dose of 200 to 250R following attack.

Both somatic and genetic effects are believed to be directly related to the dose received by the surviving population. Thus, if by effective civil defense planning, the protection provided the population could be doubled, the numbers shown here would be cut in half.

PANEL 7

GENERAL PREDICTIONS*

"20,000 additional cases per year of leukemia during the first 15 or 20 years postattack followed by an equal number of cases of miscellaneous cancers, added to the normal incidence in the next 30 to 50 years, would constitute the upper limiting case. They would be an unimportant social, economic, and psychological burden on the surviving population."

"The genetic effects would be lost as at Hiroshima and Nagasaki, in all the other 'background noise.' "

*From Proceedings of the 1967 Symposium on Postattack Recovery from Nuclear War, National Academy of Sciences, April 1968 (AD 672 770).

RANGE OF INITIAL NUCLEAR RADIATION

The threat of exposure to injurious amounts of initial nuclear radiation is confined within a radius of about 3 miles from a nuclear detonation. Thus, our hypothetical person standing in the open at 3-1/3 miles from the ground zero of a 5-MT surface burst would be subject to an altogether negligible exposure of less than 1 Roentgen. In this table, the radiation exposure in the open is related to blast overpressure for the 1-, 5-, and 25-megaton surface bursts we have been considering. Significant exposures are limited to the severe damage region where survivors would be expected only in basements or other belowground shelter areas and are most significant for the lowest-yield weapon (1 megaton).

The amount of initial nuclear radiation at a given location on the earth's surface is related to the slant range from the detonation. If a burst were to occur at higher altitudes rather than near the surface, the initial nuclear radiation would be reduced at the given point. The extent of blast overpressures could be increased, moreover. Therefore, the near-surface burst presents the most severe initial nuclear radiation threat with respect to concurrent blast effects.

It will be noted in the table that the initial nuclear radiation from surface and near-surface bursts is not greatly different. For 1-megaton detonations, the exposure in the open approaches lethal levels above 12 psi. In Chapter 1, we saw that the majority of Soviet missile warheads have a yield of about 1 megaton. In Chapter 2, we saw that there were many potential shelter areas, mainly in basements, where people could be expected to survive at overpressures of 12 psi or more. Moreover, initial radiation exposures would be additive to subsequent exposure to fallout radiations, which is discussed in Chapter 6. Therefore, an understanding of the protection afforded by basements and underground shelter areas against initial nuclear radiation is important.

PANEL 8

RELATIONSHIP OF BLAST AND INITIAL NUCLEAR RADIATION

(Near-Surface and Surface Bursts)

Blast Overpressure (psi)	Nuclear Radiation (Roentgens)		
	1 MT	5 MT	25 MT
1	Neg.	Neg.	Neg.
2	Neg.	Neg.	Neg.
5	Neg.	Neg.	Neg.
12	280 (260)*	7 (7)	Neg.
20	3600 (3200)	430 (420)	10 (10)

*Values in parentheses are for surface bursts.

PROTECTION AGAINST INITIAL GAMMA RADIATION

Here we show again the table of relative blast protection given in Chapter 2. A measure of the protection afforded against initial nuclear radiation (INR) has been added in parentheses.

The measure is given in terms of an "INR protection factor (IPF)," which is the ratio of the dose in the open to the dose in the location described, at the same distance from a nuclear detonation. A high protection factor means good radiation protection.

The lower number shown relates to locations near entrances, windows, and other openings where protection is least; the higher number pertains to locations remote from such openings. Since blast protection is also least near such openings, avoiding these areas for the sheltering of people, as described in Chapter 2, will increase the protection against initial nuclear radiation.

It can be seen that aboveground parts of buildings offer little protection—about a factor of 5 at the most. Most survivors in the region above 12 psi will be in basements, subbasements, and underground areas. Here, the protection factor is at least 10 and can be as high as 10,000, except in residential basements where a factor of 10 is the most to be expected. Survivors in residential basements could thus receive as much as several hundred roentgens.

Except in these areas, initial nuclear radiation does not appear to be an important threat to life so long as the large nuclear weapons ascribed to the Soviet Union in Chapter 1 constitute the major threat. The emergency planner needs to know the facts about initial nuclear radiation largely because smaller nuclear weapons may become important in the foreseeable future.

PANEL 9

TYPICAL INR PROTECTION FACTOR RANGES RELATIVE TO BLAST PROTECTION

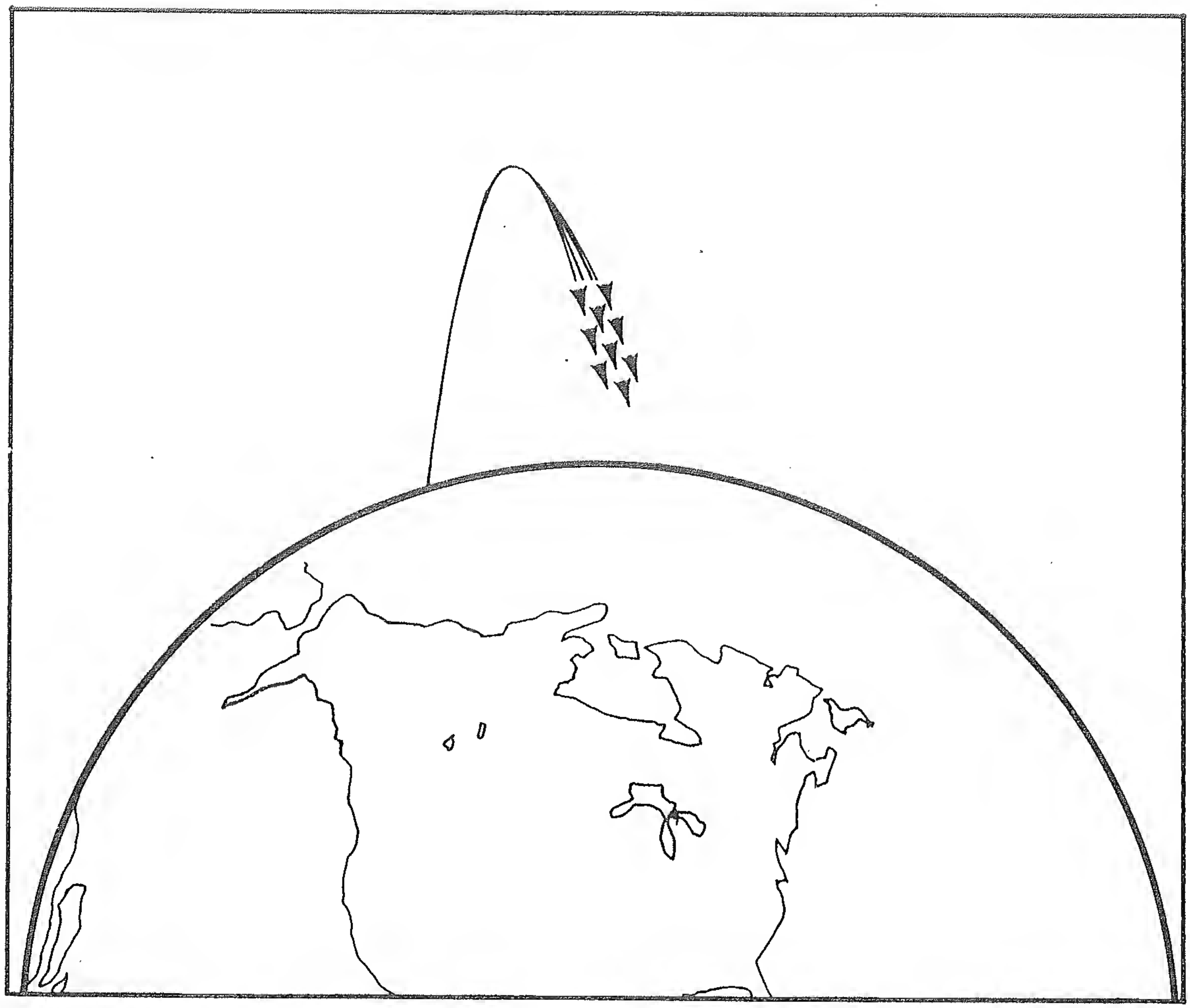
Blast Preference	Description
A	Subway stations, tunnels, mines, and caves with large volume relative to entrances. (10 - 10,000)
B	Basements (10 - 100) and sub-basements (100 - 1000) of massive (monumental) masonry buildings.
C	Basements (10 - 100) and sub-basements (100 - 1000) of steel and reinforced-concrete framed buildings having flat slab or slab and beam ground floor construction.
D	First three floors of buildings with "strong" walls. (2 - 5)
E	Basements of wood-frame (4 - 8) and brick veneer residences. (5 - 10)
F	Fourth and higher floors of buildings with "strong" walls. (1 - 5)
G	Basements of steel and reinforced-concrete framed buildings with flat plate ground floor. (10 - 100)
H	First three floors of buildings with weak walls, brick buildings and residences. (2 - 5)
I	Fourth and higher floors of buildings with weak walls. (1 - 5)

THE POSSIBLE USE OF "SMALL" WEAPONS

In Chapter 1 we alerted the emergency planner to the fact that there has been and likely will continue to be a trend toward larger numbers of smaller-yield nuclear weapons fitted on missiles as multiple warheads. We noted that many U.S. missile systems have already been modified in this fashion and that the Soviets may be beginning to do so.

Some of the motivation to use multiple warheads has stemmed from a perceived need to complicate the task of developing ballistic missile defense systems, commonly called ABM systems, by providing many separate incoming warheads. But this objective is not the whole motivation Although the total megatonnage that can be delivered in the form of multiple warheads is substantially less than that delivered as single weapons, the sum of the separate direct effects areas are very much the same. The blast effects would be somewhat lessened; the thermal effects would be somewhat increased. As we shall see, the relative effects of initial nuclear radiation are greatly increased, so that survival in ordinary structures may be limited by the lack of initial radiation protection. Since many smaller detonations may cover a sprawling metropolitan area more efficiently or permit more effective attack against separated industrial facilities, airports, and other key targets, the trend toward warheads in the kiloton-yield range may continue despite agreements to limit the deployment of missile defense systems.

Small-yield nuclear weapons in the range of tens to hundreds of kilotons also may differ from large megaton-range weapons in the nuclear processes employed in creating an explosive release of energy. About half the energy in large-yield weapons comes from fission of heavy elements like uranium. The remainder comes from fusion of light elements, such as hydrogen. Small-yield weapons may use only the fission process, as was the case at Hiroshima and Nagasaki. In describing large-yield weapons, we have assumed 50 percent fission yield. In describing small weapons, we will assume 100 percent fission yield.



PANEL 10

INITIAL NUCLEAR RADIATION FROM "SMALL" WEAPONS

When the explosive power of a nuclear weapon is changed, the extent of blast overpressure varies as the cube root of the change in explosive power. Thus, the extent for a 5-KT detonation is 1/10 that of a 5-MT detonation (one that has 1,000 times more explosive power) and the extent for a 40-KT detonation is 1/5 that of a 5-MT burst. The extent of initial nuclear radiation is reduced somewhat but not nearly as much as are the blast overpressures. Consequently, the INR exposure becomes increasingly large at a given overpressure as the weapon yield is reduced, as shown here.

At these short ranges (5-psi overpressure occurs at a mile or two from ground zero), neutrons are an important constituent of initial nuclear radiation in addition to gamma radiation. Whereas gamma radiation is electromagnetic radiation, neutrons are extremely tiny particles of matter ejected from the nuclei of atoms involved in the nuclear detonation. Neutrons have about the same effectiveness in causing biological damage as gamma rays. The use of Rem (Roentgen-equivalent-man) in the table merely signals that radiation other than gamma radiation is contributing to the exposure.

For 40-KT detonations, initial nuclear radiation is significant in the moderate damage region (2 to 5 psi). Further, our imaginary person in the open at 10 psi (about 7/10 mile from Ground Zero) is exposed to about 8000 Rem. The protection afforded by a residential basement (5 to 10 IPF) would be insufficient. Only the better parts of large building basements, sub-basements, and subways would permit survival.

At higher yields (over 100 KT), INR doses in the area of severe damage would not be as high but basement protection would be essential and survival possibilities are clearly limited by the initial nuclear radiation exposure.

RELATIONSHIP OF BLAST AND INITIAL NUCLEAR RADIATION

(Near-Surface Bursts)

Blast Overpressure (psi)	Nuclear Radiation (Rem)		
	40 KT	100 KT	1 MT
1	1	Neg.	Neg.
2	5	Neg.	Neg.
5	560	170	Neg.
12	10,000	5,500	280
20	34,000	23,000	3,600

PANEL 11

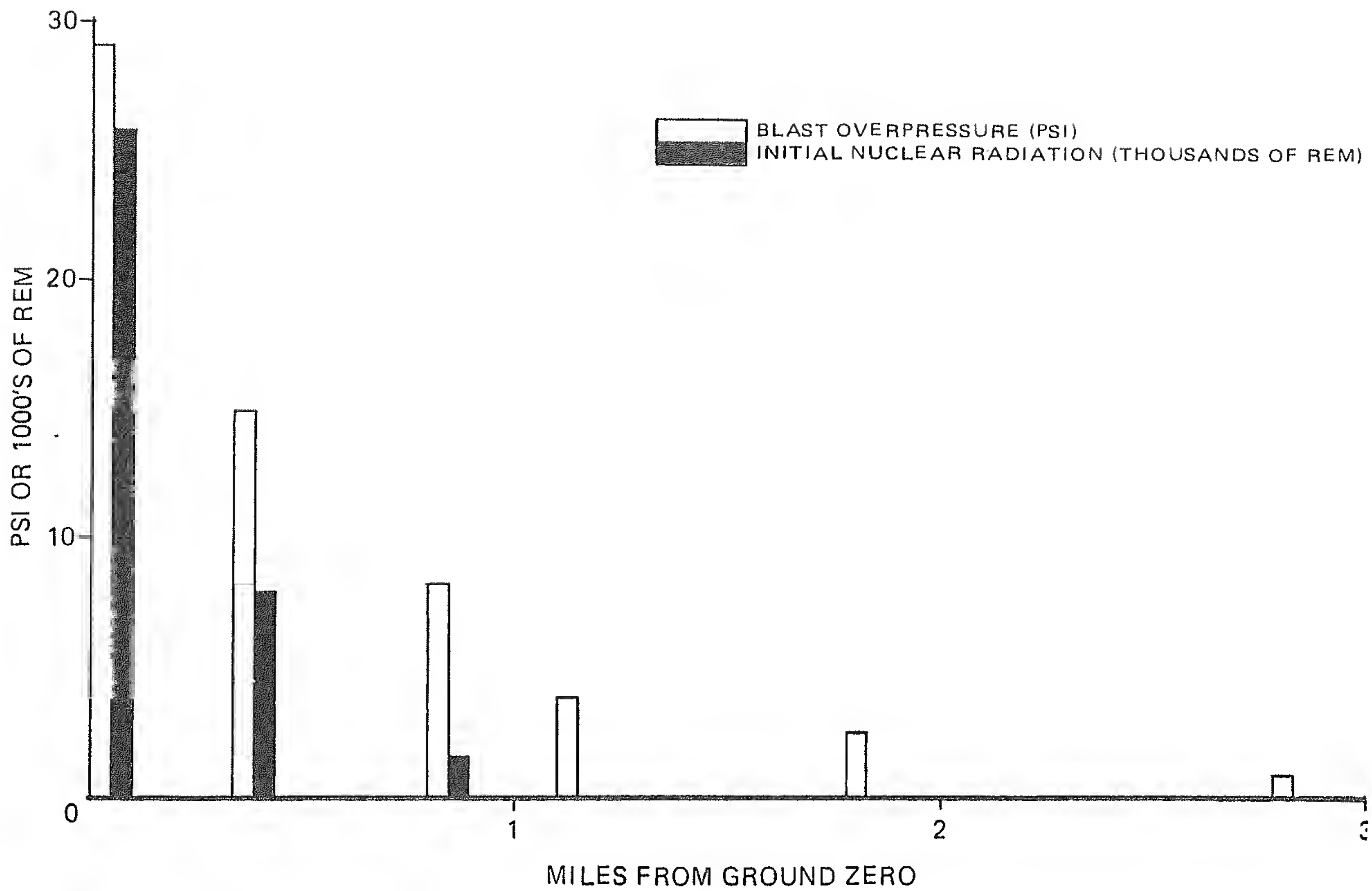
WHAT HAPPENED AT HIROSHIMA

At Hiroshima, casualties were the result of a combination of the three major "direct" effects (blast, thermal radiation, and initial nuclear radiation) but blast and thermal radiation seemed to be the dominant causes. The weapon was relatively small (about 12 KT) and exploded very high (about 1900 feet) relative to its size. It was a clear morning with a large number of people in the streets at the time. The maximum blast overpressure was about 30 psi on the ground directly under the bomb and the initial nuclear radiation dose there was about 26,000 Rem. However, the initial nuclear radiation exposure reduces rapidly with increased distance from the weapon. Both the overpressures and INR doses for several distances at Hiroshima are shown in this bar chart.

At 8-psi blast overpressure, where more than half the people in Japanese houses were killed, the initial nuclear radiation exposure was about ½ percent of its maximum or 155 Rem, too low to cause death. If the weapon had been detonated nearer the ground (within a few hundred feet), initial nuclear radiation would have been a more important cause of death than either blast or thermal radiation. For example, at 8 psi, the initial nuclear radiation exposure in the houses would have been 2800 Rem.

In discussing the threat of initial nuclear radiation, we have assumed that surface or near-surface detonations would occur. If this is not the case, this threat will be greatly diminished.

BLAST AND INR* AT HIROSHIMA



*From Auxier, J.A., et al., **Free-field Radiation-dose Distributions from the Hiroshima and Nagasaki Bombings**, Health Physics, Vol. 12, 1966.

PANEL 12

BLAST EFFECTS OF "SMALL" WEAPONS

Although the use of multiple warheads consisting of many small nuclear weapons by the Soviet Union is a possibility that may not materialize, the emergency planner should keep in mind the ways in which the other direct effects of small weapons differ from those in the megaton-yield ranges that have been emphasized so far. In addition to initial nuclear radiation, there will be changes in the blast and thermal effects. These changes will be most apparent in the 40 to 100 kiloton range.

Shown here is the general picture of the blast protection afforded by ordinary buildings. The median lethal overpressure values given in Chapter 2 for megaton-yield weapons is shown in parentheses. One can see that, in general, people survive at higher overpressures for low-yield explosions. At 40 KT, the blast wind persists for about one second. Debris is not blown about as violently as in megaton detonations. Since people are injured mainly by blast wind effects, casualties are significantly reduced at corresponding overpressures.

It should be kept in mind, of course, that a table such as this is approximate. The variations due to strong or weak walls and to the design of ground floors over basements would still influence the blast protection afforded by specific buildings. However, the hazard of being blown out of upper stories would be greatly reduced, as would the effects of air blast penetrating into basement rooms. Debris, of course, would tend to remain on site, with less interference with movement but more problems in search and rescue of trapped survivors.

And, because of the generally increased survivability at given overpressures, the potential threat from initial nuclear radiation would be increased.

BLAST PROTECTION IN CONVENTIONAL BUILDINGS

(From Low-Yield Weapons)

Location	Median Lethal Overpressures	
	Residences	NFSS Buildings
Aboveground	7 psi (5)	9 psi (7)
Belowground	12 psi (10)	14 psi (12)

PANEL 13

FIRE EFFECTS OF "SMALL" WEAPONS

The extent of thermal radiation from kiloton-yield weapons is less at corresponding blast overpressures than for megaton-yield weapons, as shown in the upper table. On the other hand, the thermal energy is delivered in a much shorter time period. Hence, the critical ignition energies are lower. The result is that the limit of significant ignitions remains about the same—approximately the range of 2 psi blast overpressure.

Visibility conditions affect low-yield weapons less than large-yield weapons because of the short ranges involved. Air bursts of low-yield weapons extend the range of low overpressures more than the thermal effect. The experimental evidence on the extinguishment of ignitions by the blast wave applies to low-yield weapons as well as high-yield weapons.

PANEL 14

RELATIONSHIP OF BLAST AND HEAT
(Surface Burst on a Clear Day)

Blast Overpressure (psi)	Heat Radiation (cal/sq cm)		
	40 KT	100 KT	1 MT
1	4	4.5	6
2	10	13	21
5	35	46	100
12	105	137	350
20	175	270	560

IGNITION ENERGIES FOR KINDLING FUELS
(cal/sq cm)

	Weapon Yield		
	40 KT	100 KT	1 MT
GROUP I			
Crumpled newspaper, dark picture	5	6	7
Black lightweight cotton curtains	3	4	6
Dry rotted wood & dry leaves	4	5	6
GROUP II			
Beige lightweight cotton curtains	10	15	32
Kraft corrugated paper cartons	16	18	--
White typing paper	24	26	30
Heavy dark cotton drapes	12	13	22
GROUP III			
Upholstered Furniture	12	16	28
Beds	8	11	22

SUMMARY

We can summarize what the planner needs to know about initial nuclear radiation by pointing up the following facts:

(1) Given the large-yield weapons that the Soviets have at present, initial nuclear radiation is mainly of interest to the designers of blast-resistant structures and in the survey of best available shelter from direct weapons effects.

(2) If multiple-warhead weapons of low yield should be deployed by the Soviets, many areas that would offer good blast protection may not offer sufficient protection against initial nuclear radiation. In effect, there would be less "all-effects" protected space in existing buildings.

(3) As will be seen in the next Chapter, radiation doses from initial nuclear radiation and fallout are additive. Thus, less than lethal exposures to initial nuclear radiation can make subsequent exposure to fallout radiation a very serious matter under current fallout protection standards. This will be of significance for survivors inside the 12-psi region from the many 1-MT weapons that currently are part of the Soviet threat.

INITIAL NUCLEAR RADIATION

IS IMPORTANT:

(1) CURRENTLY, MAINLY TO DESIGNERS OF BLAST-RESISTANT STRUCTURES AND IN ALL-EFFECTS SURVEYS.

(2) IF AND WHEN LOW-YIELD MULTIPLE WARHEADS BECOME A THREAT.

(3) BECAUSE ANY INITIAL RADIATION EXPOSURE WILL REDUCE THE ABILITY TO COPE WITH SUBSEQUENT FALLOUT RADIATION EXPOSURE.

SUGGESTED ADDITIONAL READING

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